Ene-39.2001 Thermodynamics and Heat Transfer
Exam 19.12.2009 at 10-14, part II (at 13-14).
Problems 5-6 with no material (at 13-14).

5. According to the second rule of thermodynamics, the following equation holds for the entropy change in any process:

$$S(B) - S(A) \geq \int_A^B \frac{dQ}{T}.$$

a) Show, by using this and the general energy balance that in a process where T = constant and p = constant, the system always tends to go to the stabile balance state, where The Gibb's energy gets the minimum value.

b) Show, based on part a, that in the balance state of saturated water and saturated steam the temperature is determined by the pressure and on the contrary - the pressure is determined by the temperature, that is, p = f(T) and T = g(p).

6. In this problem, use value c_p = 1,0 kJ/kgK for the specific heat of the air.

a) Air is accelerated in a nozzle from zero velocity up to velocity 240 m/s. The air enters the nozzle at 20°C. Calculate the temperature of the air discharging from the nozzle.

b) Air enters a choke valve at 20°C and 7 bar. The pressure drops down to 2 bar. What is the temperature of the air after the choke if velocities are negligible.

c) Air is supplied by a fan into an electric heater at the rate of 1 m³/s at 20°C. The air is warmed up in the heater to 60°C and the pressure drop in the heater is 5 kPa. Flow velocities can be neglected. Calculate the electric power of the heater.

d) Calculate the shaft power of the fan in part c as the (isentropic) efficiency of the fan is 0,65.